Feature Painting from 2-D Feature Grids and 3-D OSO Models onto 2-D Cartesian and Cylindrical Grids

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Feature painting allows mesh designers to add detail to primary, base meshes by overlaying them with separately meshed shapes, or features. This ability to overlay meshes saves designers from the considerable effort of creating complete meshes directly, beginning again from scratch if a feature's position, orientation, or size is changed. We have developed two feature-painting libraries, `intergrid` and `interpoint`.

A particular application of feature painting consists of beginning with a base mesh whose cells are of one material, overlaying a feature mesh whose cells are of a different material, and then computing for each base cell the volume fraction of new, feature material. For example, if a particular base cell is four-tenths covered by the feature grid, then that base cell should receive a volume fraction of 0.4.

Precise per-cell volume fractions can be used by codes that allow for multimaterial cells. Other codes can arrange for "stair-stepping:" volume fractions less than 50%, for example, can be clipped to 0, and those 50% or more clipped to 1.

`intergrid`

To use `intergrid` ("intersect grid"), users supply general, unstructured 2-D grids with convex cells for base and feature. Material information may also be provided. For each base cell of a selected material, `intergrid` computes all of the cell's intersections with any feature cells, and computes the volume fraction of feature material appearing in that cell. The grids may be regarded as Cartesian or cylindrical; `intergrid` uses the appropriate volume weighting in each case.

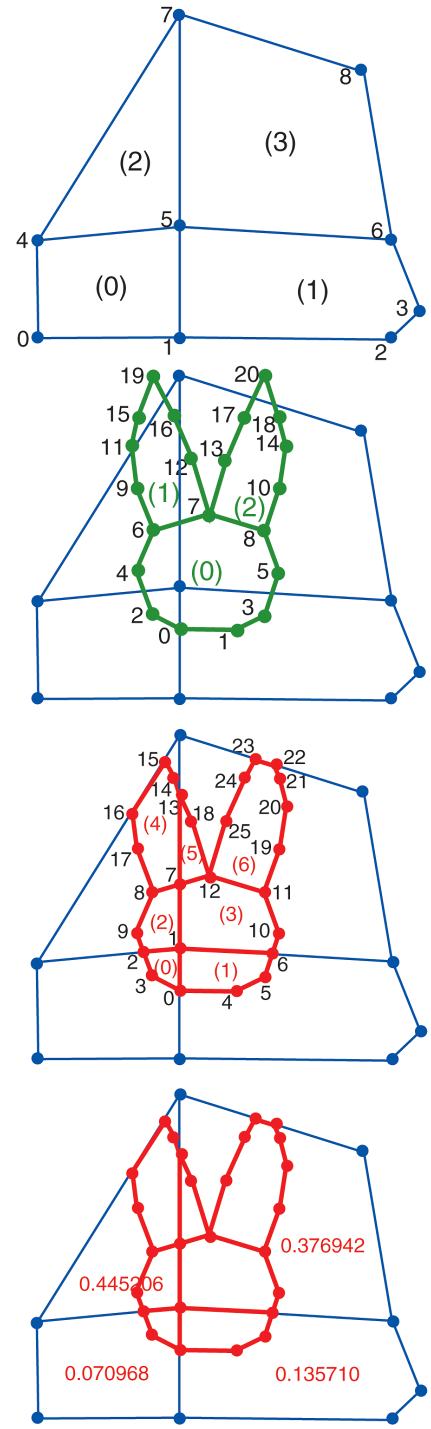

Fig. 1.
a) Sample base grid; b) feature grid; c) intersection of base and feature, as computed by `intergrid`***; and d) computed volume fractions.***

The trickiest part of this computation is the determination of cell intersections, a seemingly simple action whose robust and efficient implementation in fact requires considerable care.

An important aspect of our implementation was to design an efficient computation of all cell intersections. If the base and feature grids each have 10^7 cells, for example, we certainly want to attempt far fewer than 10^{14} intersections.

Figure 1 shows a sample base grid, with nodes enumerated in dark blue and cells parenthesized in black. We then overlay a rabbit feature, enumerated similarly. The third frame shows the intersection grid as computed by `intergrid`, and the fourth frame shows the computed volume fractions, one per base cell.

`interpoint`

This similarly named extension to `intergrid` accepts an unstructured 2-D base grid as before, now allowing for non-convex cells, plus a feature given in terms of an arbitrary slice through an OSO model. For a selected base material and region of interest in the OSO model, `interpoint` uses point queries (hence the name `interpoint`) to compute volume fractions. We don't use cell intersections, as before, because features now come from constructive solid geometry models, not from grids. Like `intergrid`, this library supports both Cartesian and cylindrical volume weightings.

Figure 2 again shows our sample base grid, followed by an OSO feature model. The third frame shows the locations (in 2-D) of point queries, with red indicating values inside the OSO model. Finally, the fourth frame shows the computed volume fractions.

Both libraries are written in ANSI standard C++, and include C-language interfaces. Each library requires the simple inclusion of a C++ header file, without complex makefiles, configure scripts, or library linking. We also have augmented each library with a set of MATLAB® codes for visualization, and with example codes and a test suite.

For more information contact Martin Staley at staley@lanl.gov.

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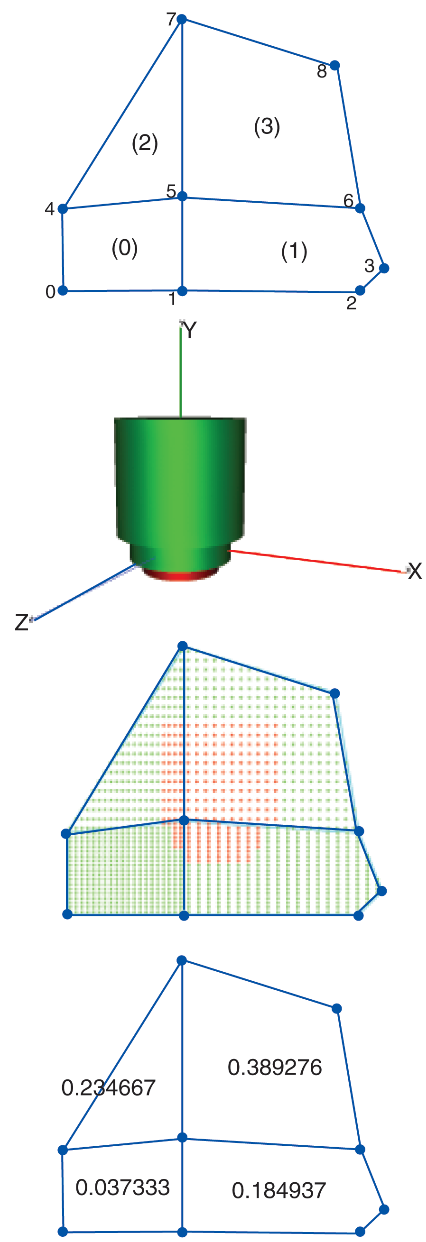

Fig. 2.
a) Sample base grid; b) OSO feature model; c) point-query locations in 2-D; red indicates intersection with OSO feature when transformed to 3-D; and d) computed volume fractions.